

VISUAL PERCEPTION AND EVALUATION OF ARTIFICIAL NIGHT
LIGHT IN URBAN OPEN AREASVIZUALNA PERCEPCIJA I OCJENA NOĆNE RASVJETE U GRAD-
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Građevinski fakultet, Sveučilište u Mariboru, Maribor, Slovenija**Abstract*

The article explores holistic approach of understanding the importance of qualitative lighted urban environment. Night illuminations have an important visual potential. A night city appears quite different as during daytime. A concept of urban landscape is not only material reality, but it is also a mental structure that results subjective perception. Analytical research work discovered that environment perception differs during day and night. In the evening, attention is focused on light effects. Only illuminated points act as landmark. Both, bright and dark surfaces have an impression of districts. The role of main paths overtakes illuminated corridors. Recognition of nodes and edges is depended of the lighting intensity. The article represents different illuminated examples and provides guidance for qualitative lighting of urban open areas. Methodology of city lighting evaluation was developed during research work. The paper delivers an explanation of evaluation criteria which were considered. The research results show, that appropriate lighting arrangements are: suitable to everyone, environmental acceptable and cost-effective. Only such lighting arrangements provide best living condition to all and have development potential. The study results are useful as an innovative approach in spatial design. Clever lighting solutions allow achieving a high level quality at low energetic costs. Lower costs mean effective contribution to economic growth that stimulates urban development.

Sažetak

Članak istražuje holistički pristup razumijevanju važnosti kvalitete rasvjete u urbanom otvorenom prostoru. Noćne iluminacije imaju važni vizualni potencijal. Noćni grad izgleda sasvim drugačije nego tijekom dana. Koncept urbane krajine je za korisnike ne samo materijalna stvarnost, to je mentalna struktura koja rezultira subjektivnu percepciju. Analitički istraživački rad je otkrio da se percepcija okoline (mentalna slika), razlikuje tijekom dana i noći. U večernjim satima, pozornost je usmjerena na utjecaj svjetlosti. Samo osvijetljene točke djeluju kao orijentir. Obje, svijetle i tamne površine imaju utisak okruga. Ulogu glavnih puteva preuzimaju osvijetljeni hodnici. Identifikacija čvorova i rubova ovisna je od jačine rasvjete. Članak predstavlja primjere osvijetljenja i daje smjernice za kvalitativnu rasvjetu urbanih otvorenih površina. U kontekstu znanstvenog rada razvijena je metodologija procjene rasvjete. Rad prikazuje kriterije ocjenjivanja koji su bili uzeti u obzir. Rezultati studije pokazuju da su odgovarajuća rasvjetna rješenja društveno prihvatljiva, ekološko prihvatljiva i ekonomsko učinkovita. Samo takvi uspješni rasvjetni aranžmani omogućuju dobre uvjete za život svih. Rezultati studije su korisni kao inovativni pristup u prostornom planiranju i dizajnu. Pametna svjetlosna rješenja omogućuju visoku razinu kvalitete s niskim energetskim troškovima. Niži troškovi znače učinkovit doprinos gospodarskom rastu koji potiče razvoj grada.

1. INTRODUCTION

Light is an important environmental factor. As a source of energy it affects the entire life on the planet. It is one of the most efficient message carriers. Eyesight provides the largest amount of information, to explain what happens around us. Vision gives us two-thirds of environmental information /1/. The most frequent lighted surfaces of urban environment are: traffic areas (public streets, railways and airports), public areas (squares, parks), production areas, business buildings and institutions, recreation grounds, cultural memorials, advertising surfaces and conditionally dangerous areas.

Dealing with artificial night light requires holistic approach. In the evening, attention is focused on effects of light. Urban environment covers many different spatial interests. In order to please them all, there are numerous more or less successful lighting arrangements. Presence of night light increase visibility of traffic situation, increase personal security, decrease grade of vandalism and make better orientation possible. Light is needed to satisfy all quality parameters of living inside urban environment. Generally it can be said, artificial night light makes urban environment more pleasant for us. Light becomes visual city designer in order to serve inhabitants.

Rhythm of all living beings (humans, animals and plants) is highly dependent on light. But every additional illumination changes natural circumstances. Natural environment is modified. Not only animals, humans are affected as well. Too much light or light pointed in wrong direction increase unpleasant feeling, lowers the residential potential, provide high energetic costs due to energy loss and raises emission of warm house effect. Illumination is not always functional. Useless illumination makes visual irritation possible and prevents appropriate respond to events. Troubles appear when there are such conditions that human visual system can't quickly adapt. Too less or

too much light on one particular spot is felt uncomfortable, the reaction on specific situation can be wrong. Good communication between environment and user is a prerequisite for his well-being. But a night city appears quite different as during daytime, it is difficult to adapt to it.

A starting point of presented research is a question: (1) how the perception of environment can be equal well during day and night time and (2) how to provide good lighting arrangements? It is supposed that good lighting arrangements are a precondition for successful environmental perception. In this regard the problem is how to rich that the light should be pointed only there where we need it. An appropriate lighting evaluation should be taken. But which type of evaluation is appropriate? The article presents theoretical tool to evaluate lighting arrangements quality and its potential.

2. ENVIRONMENTAL PERCEPTION OF A CITY AND USERS' DEMANDS

City structure represents a basis that helps humans in perception and spatial orientation /2/. Lynch /3/ divides urban space on individual components: points, lines, surfaces and volumes. It is important their hierarchy, size, and visual recognition. Lynch /4/ also noticed five key elements with a great recognition value that makes reading spatial order possible. These are paths, edges, districts, nodes and landmarks.

Paths are linear elements along that the observers move. For many of us they are dominant elements in space perception. Edges are linear elements that appear as a dividing line between two areas. Districts are closed spatial units as well as areas of concentration or dispersion. Nodes are strategic spots allowing entrance from all possible directions. Landmarks are more or less exposed unique objects in the area.



Image 1: Paths, edges, districts, nodes and landmarks; key elements of urban structure /2/

Perception of all listed elements differs during day and night. Lighted elements are more visual. Complete new relationship between them is created. A boundary between light and dark is the most powerful contrast who defines relations between buildings and open space. Light increase visual city value. Lighted surfaces have a great recognition potential and make recognizing spatial order and structural connections possible. That strengthens spatial identity. Only illuminated points act as landmark. They should be lighted intensive and colourful. Both, bright and dark surfaces have

the impression of districts. The role of main paths overtakes illuminated corridors. Exposure mode establishes a new hierarchy of routes and areas. Recognition of nodes and edges is also depended on light intensity. Thoughtful lighting of Lynch components is important because it increases mental city awareness, increases recognition of structural connections and strengthens spatial identity. Visual averseness of night environment becomes much better, good orientation ability is provided.



Image 2: Castle square (Maribor, Slovenia)
The place act like a node. A vertical of the castle is a dominant object and orientation point.



Image 3: Castle square at night (Maribor, Slovenia)
The vertical of the castle is not visible. Narrow lighted path near buildings is generator of space. Light coming through windows is noticeable.

The last is very important because urban surfaces are always used by many users at the same time; like: drivers, cyclists, pedestrians, residents. Each group has their own spatial needs. There are many different recommendations to arrange good visual surface. Lighting should go along with it and create good personal feeling. Sometimes many lighting objects are placed to satisfy all users, but illuminated ambience is not necessary good.

Lighting for no reason is not effective. It is important to know which elements are illuminated, what is illumination purpose and what is the appropriate way to achieve a good result.

Luminaries can be installed in many different ways: on the building, on the ground in front of the building, on the entrance portal or on a neighbourhood building, which is not the focused subject. The choice of right position and right type of luminaries is as important as how much light is actually reflected into the environment. Technical characteristic make luminaries come up to users. Not shaded luminous are not suitable. The best choice is completely shaded luminous. Those one light equally and have minimal glow.

The effect of the exposed object occurs when the spot illumination exceeds the level of light

in the surrounding area. Dark surrounding requires much less light to achieve the same explosion effect as bright environment. Our eyes are slightly adapted to dark and have an ability to detect very small changes. Light coming through buildings windows has additional advantage of good spatial designer.

Material and texture of illuminated surface is important too. Dark surfaces absorb much more light than light; smooth surfaces reflect more than structured. For reflective surfaces different approaches should be used. Lamps should be positioned above eye level to prevent glow.



Image 4: Leon Štukelj square (Maribor, Slovenia) Longitudinal path is pointed out. Object on the edge do not include or articulate the market space.

An appropriate colour choice is important. White or yellow shades are usually needed, especially for traffic objects and pedestrian areas. Decorative illumination use larger colour scale. It is depended on spatial designing component. Colourful Illuminated elements create visual leading and they are categorized as more noticeable.

Santen /7/ recommends that the highest point of object should be illuminated more than the bottom in order to achieve a uniform object perception. Observers' eye level is taken into account; lights are not installed on that high. Detection of object unity increases with distance illumination, but distance causes light diffuse. Lighting from the bottom up is not appropriate. Pointing light from top to bottom is only acceptable.

Quality lighted environments have larger visual potential; they can be more attractive and therefore frequently used. Luminaries are important aesthetic designed elements inside ur-

ban structures /8/. Strongly structured surfaces throw a lot of shadows. Interplay of light and shadow creates visually appealing components. Their appearance should be consistent, excessive contrast between light and shadow is unsuitable. The problem can be solved by simultaneous backlit different angles /5/. Straight flat surfaces do not cast shadows. The perception of their multi dimension is created by different intensity and light colour.

According to Veitch /6/ the most acceptable are vertical constant illuminated smooth surfaces. The same one are also judged as uninteresting. Colour contrasts are accepted as interesting as well as spotted illumination.



Image 5: Leon Štukelj square at night (Maribor, Slovenia) Space character is changed. Light beams are focused on paved surface and articulate the space.

ban structures /8/. But not only visual effect is important. Safety feeling is users' priority. Pinter and Farington /9/ report that the lighting optimization increase feeling of safety and decrease criminal activities for 15 %. Improved ambience lighting had positive effect and reduced public costs spend to prevent criminal. But how much light do we need to achieve positive effect? According to Boyce /10/ additional light in low illuminated surfaces (between 0 and 10 lx) increase our safety perception. If departure illumination is high (50 lx or more), additional light make no sense. According to all that, the most suitable illumination grade is about 30 lx. That enables us to recognize danger from far away.

3. LIGHTING EVALUATION METHODOLOGY, DIMENSIONS, FACTORS AND INDICATORS

Urban environment has constantly changing parameters. Lighting arrangements should be able to adapt to all spatial conditions. In practice, changing circumstances often mean different traffic density, new land use or changing users quantity in rush or late night hours. To ensure good living conditions during the night, artificial night lighting should be adjusted as continually evolving process. Strong lighting is not enough, light must be functional. Suitable lighting is not a fixed situation; it is a set of wishful characteristics of a complex system.

Using information obtained by different authors, a three-domain scheme was created using the method of inductive conclusion in order to evaluate lighting arrangements quality. It is assumed that suitable lighting follows the same principles as other areas of urban arrangements. Sustainability as a process, that impacts development of all aspects of human life, is the highest priority. Sustainability means resolving the conflict between various competing goals. It involves the simultaneous pursuit of economic efficiency, environmental responsibility and social cohesion also known as three-domain model of the triple bottom line /11/. Therefore lighting evaluation scheme also bases on three dimensions like: (1) Suitability to everyone, (2) Environmental acceptance and (3) Cost-effectiveness.

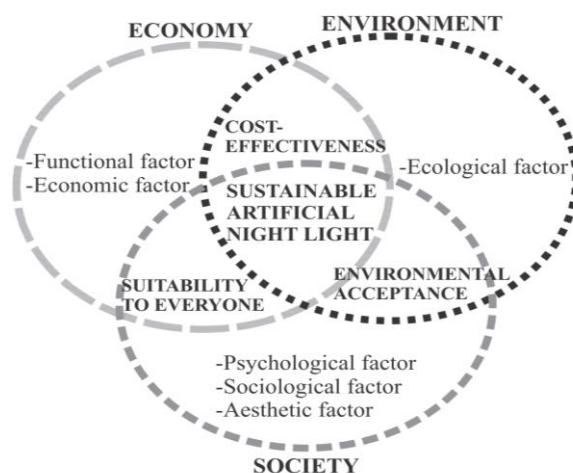


Image 6: Lighting evaluation scheme based on three dimensions like Economy, Environment and Society

Sustainable artificial night light of urban areas means keeping or improving the quality of lighting arrangements. To ensure good living conditions luminance should be adjusted to concrete spatial situations. Maintenance of biodiversity and natural elements is high development priority. Absence or reducing the illumination does not necessary mean lower life quality. Darkness automatically means annihilation of all negative illumination impacts as well as reduction of energy costs. Low costs are essential for a successful sustainable city development.

4. THREE DIMENSIONS EVALUATION MODEL

After analytical research work on different spatial case studies a model was developed to study lighting situation, evaluate lighting potential of concrete location and respond to spatial circumstances. Three dimensions model – Suitability to everyone, Environmental acceptance and Cost effectiveness (SEC model) was created using information obtained by method of inductive conclusion. Dimensions have associated factors like: psychological, sociological, aesthetic, ecological, functional and economic (Table 1). Each factor has appropriate indicators listed below in order to evaluate the importance of specific factor.

Table 1: SEC model - three dimensions evaluation assessment of artificial night light in urban environment

SEC MODEL	DIMENSIONS	FACTORS	INDICATORS
SUSTAINABLE ARTIFICIAL NIGHT LIGHT	1. Suitability to everyone to assure individual well being	1.1 Psychological	• Individual feeling
			• Identification of environment
			• Orientation ability
			• Sense of safety
		1.2.Sociological	• Land use
		1.3.Aesthetic	• Ability to recognize space order
	• Ability to recognize space segmentation		
	• Illumination effects		
	2. Environmental acceptance	2.1 Ecological	• Impact on habitats
			• Impact on living creatures (plants and animals, act.)
	3. Cost effectiveness	3.1 Functional	• Reflection of illuminated surface
			• Adequacy of installation lighting infrastructure
			• Complexity of lighting infrastructure maintenance
• Appearance of lighting infrastructure during day and night			
3.2 Economic		• Energy cost	
		• Lighting infrastructure installation cost	
	• Lighting infrastructure maintenance cost		

It is assumed that all factors and associated indicators are not equally important. Statistic calculation of causal links between them is possible. Calculation of multiple regression allows determining the importance of each indicator on the corresponding factor. Among the factors correlation links could be calculated.

5. CONCLUSION

We can't imitate daylight. It changes every moment in colour and intensity. This effect is not repeated. But its function can be replaced. Lighting represents specific environmental design. It is important to determine visible or highlighted spatial components, to define a purpose of lighting, to decide what type of luminaries should be used, where they can be placed and last but not least to discover who is the place resident or occasional user.

Urban environment is basically controlled and designed by our measures. Presence of the light during the dark time of the day increase visibility, personal security and make better orientation possible. Generally we can say artificial night light makes our environment more comfortable and allows us an appropriate respond to environmental circumstances. But space perception during night and day is not

the same, consequently lighting arrangements are not always successful. Light should be pointed only there, where we need it. This is basic lighting rule. Useless illumination is sensed as development weakness because it provides waste of energy and high operating costs. A challenge is how to provide artificial night light suitable to everyone, environmentally acceptable and cost effective. There are many limitations which should be considered, like: spatial circumstances, users' demands, functional demands, economic demands and nature conservation demands. Evaluation model was developed to study lighting situation and evaluate lighting potential of urban situation. SEC methodology helps us to respond on users demands. Consequently lighting intensity of urban environment can be increased, decreased or redesigned. Evaluation results could help in solving current societal challenge: how to illuminate in a way to assure individual well being and increase visual perception of night environment as well as how to adapt lighting strategy to three pillars of development: Society Economy and Environment.

Notes

- /1/ Gregory, R.L., 1998. Eye and Brain. The Psychology of Seeing. Oxford, Oxford University Press
- /2/ Lynch, K., 1964. Image of the city. Cambridge, Institute of Technology
- /3/ Ibid
- /4/ Ibid
- /5/ Santen, C., 2006. Light Zone City: Light Planning in the Urban Context. Basel, Birkhaeuser
- /6/ Veitch, J. A., 2001. Psychological processes influencing Lighting Quality. Journal of the Illuminating Engineering Society, 30,1, pp 124-140,
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- /8/ Huber, C., 2006. Sicherheit durch Licht. Strasse und Verkehr, 2006, 9, pp 6-9
- /9/ Painter, K. A., Farrington, D. P., 2001. The Financial benefits of improved street lighting based on crime reduction. Lighting research & Technology, 33(1), pp 3-10
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- /11/ Hasna, A. M., Dimensions of sustainability. Journal of Engineering for Sustainable Development: Energy, Environment, and Health 2 (1), pp 47-57, 2007.